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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

DOCKET #: 4925-105PUS

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
09/787308

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FI99/00794	**28 September 1999**	**29 September 1998**

TITLE OF INVENTION

ADMISSION CONTROL METHOD

APPLICANT(S) FOR DO/EO/US

Niina LAAKSONEN

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x]This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. [x]This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [x]A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [x]A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [x]is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] has been transmitted by the International Bureau.
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [x]Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [x]are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [] have not been made and will not be made.
8. [] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [x]An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. Below concern other document(s) or information included:

11. [x]An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [x]An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [] A **FIRST** preliminary amendment.
    [] A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. [] A substitute specification.
15. [] A change of power of attorney and/or address letter.
16. [x]Other items or information *(specify):* PCT Publication, Int'l Preliminary Examination Report, Written Opinion, Reply to Written Opinion, Notice Informing the Applicant of the Communication of the International Application to the Designated Offices, Information Concerning Elected Offices Notified of Their Election, Notification of Receipt of Demand by Competent International Preliminary Examining Authority, PCT Demand, Notification of the Recording of a Change, Notification Concerning Submission or Transmittal of Priority Document, Int'l Search Report, PCT Request

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U S APPLICATION NO. (If known, see 37 C.F R. 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/787308	PCT/FI99/00794	4925-105PUS

17.[x]The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):
Search Report has been prepared by the EPO or JPO **$860.00**
International preliminary examination fee paid to USPTO (37 CFR 1.482)..................**$690.00**
No international preliminary examination fee paid to USPTO (37 CFR 1.482)
but international search fee paid to USPTO (37 CFR 1.445(a)(2)) **$710.00**
Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$1000.00**
International preliminary examination fee paid to USPTO (37 CFR 1.482)
and all claims satisfied provisions of PCT Article 33(2)-(4).. **$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =				**$860**	
Surcharge of **$130.00** for furnishing the oath or declaration later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	9 - 20 =		x **$18.00**	$	
Independent Claims	2 - 3 =		x **$80.00**	$	
Multiple dependent claim(s) (if applicable)			+ **$270.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$	
Reduction of ½ for filing by small entity, if applicable.				$	
SUBTOTAL =				**$860**	
Processing fee of **$130.00** for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				**$860**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by the appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED					$860
Amount to be refunded:					$
charged:					$

a. [x]Two check(s) in the amount(s) of $ 860 and $ 40 to cover the above fees is/are enclosed.
b. [] Please charge my Deposit Account No. 03-2412 in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.
c. [x]The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 03-2412. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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Admission control method

TECHNICAL FIELD OF THE INVENTION

The invention is related to radio resource usage in cellular telecommunication systems, more accurately to admission control methods used in establishing of new connections.

BACKGROUND OF THE INVENTION

In cellular telecommunication systems a single speech connection or data connection through the cellular telecommunication network is called a bearer. Generally, a bearer is associated with a set of parameters pertaining to data communication between a certain terminal equipment and a network element, such as a base station or an interworking unit (IWU) connecting the cellular network to another telecommunications network. The set of parameters associated with a bearer comprises typically for example data transmission speed, allowed delays, allowed bit error rate (BER), and the minimum and maximum values for these parameters. A bearer may further be a packet transmission bearer or a circuit switched bearer and support for example transparent or non-transparent connections. A bearer can be thought of as a data transmission path having the specified parameters connecting a certain mobile terminal and a certain network element for transmission of payload information. One bearer always connects only one mobile terminal to one network element. However, a bearer can pass through a number of network elements. One mobile communication means (ME, Mobile Equipment) may in some cellular telecommunication systems support one bearer only, in some other systems also more than one simultaneous bearers.

In order to be able to transmit information in a desired way, connections over the radio interface have to obtain a desired level of quality. The quality can be expressed for example as the C/I i.e. Carrier to Interference ratio, which indicates the ratio of received carrier wave power to received interfering power. Other measures for the quality of a connection are SIR i.e. Signal to Interference ratio, S/N i.e. Signal to Noise ratio, and S/(I+N) i.e. Signal to Noise plus Interference ratio. The bit error rate (BER) or frame error rate (FER) are also used as measures of connection quality. Typically, a certain target level for one of these or other corresponding measures is determined beforehand, and for each connection, the

transmission power is adjusted to be such that the target level is reached as closely as possible. The transmission power should not be higher than what is necessary for obtaining the desired target level, since a too high transmission level wastes electrical energy in the transmitting equipment, which is crucial with handheld mobile stations, and causes interference to other connections.

Admission control is a crucial function in ensuring, that each bearer obtains the desired SIR level. The purpose of admission control is to examine each new request for a new bearer, and determine whether the requested service can be provided without degrading the service to other bearers, taking into account the transmission power of the requested bearer. If the new bearer can be serviced without harming other bearers, the request is admitted. Admission control typically co-operates with power control, whereby the transmission power of some of the other bearers may be adjusted in order to guarantee the SIR target level of the other bearers.

Various admission control algorithms have been proposed in the past. The article "SIR-Based Call Admission Control for DS-CDMA Cellular Systems" by Zhao Liu and Magda El Zarki, I2 Journal on selected areas in communications, vol. 12, no. 4, pp. 638-644, May 1994, describes an algorithm based on the concept of residual capacity. Residual capacity is defined as the additional number of initial calls a base station can accept. If the residual capacity is larger than zero, new calls are admitted. The residual capacity is determined from measured SIR levels and a threshold SIR level.

Another algorithms are described in the article "Call Admission in Power Controlled CDMA Systems" by Ching Yao Huang and Roy D. Yates, in proceedings of I2 VTS 46th Vehicular Technology Conference, April 28 - May 1, 1996, Atlanta, USA, pp. 1665-1669. In this article, two simple algorithms are presented. In the first algorithm, a new call is blocked when that new call would cause ongoing calls to transmit at maximum power. In the second algorithm, a new call is blocked if the total received power measured at the base station exceeds a predetermined threshold.

These algorithms function well, when the calls i.e. bearers are relatively similar in terms of resource usage, and any admission thresholds are set to a level where the admission of a bearer does not increase the load too near to the maximum capacity. However, these algorithms do not function well, when the bearers have widely varying properties, i.e. when the network needs to handle both low bit rate bearers

such as normal speech bearers, and high bit rate bearers such as high-capacity data bearers or live video bearers. Such a variety of services will be provided for example by the UMTS cellular telecommunication system presently under development. For example, in the conventional algorithm in which a new call is allowed if the total received power measured at the base station is under a predetermined threshold, a high bit rate bearer may increase the network load too near to the maximum capacity. This can be prevented by lowering the threshold so that any high rate bearers allowed close to the threshold still do not increase the total load too much, but in that case, the low bit rate speech bearers end up being refused even if the remaining capacity could accommodate them.

The problem with the known admission control methods is, that they consider all bearers to have an evenly distributed bit rate usage, without regarding the differing properties of different bearers. This presents a problem in a situation, where there are bearers with widely differing characteristics within a control region, for example a large number of voice calls and a few real time video connections. A problem with high bit rate bearers is that even though the received total power in their control region is quite satisfactory, that control region may cause too much interference to some neighbouring control region because of the unequal distribution of the interfering power within it.

The document US-A-5 497 504 (Acampora et al.) describes an admission control method where a request for a connection of a certain type is first tested by checking the number of already existing connections of the same type. If that test succeeds, the request is also tested to see, whether it conforms to certain local policies. The document US-A-5 666 348 (Thornberg et al.) describes a method for handling requests for packet channel capacity. A request contains a priority value and an indicator for the estimated data traffic. The admission control algorithm considers existing packet calls that have at least as high a priority value, and admits the request if a certain sum of estimated data traffic does not exceed a maximum value.

SUMMARY OF THE INVENTION

An object of the invention is to realize an admission control method, which takes into account differences between the resource usage of different bearers. A further object of the invention is to realize an admission control method, which provides efficient and widely adjustable control over admission of both bearers using small amounts of resources and bearers using large amounts of resources.

The objects are reached by a two-part admission control method, in which a test of a first kind monitors all bearers in roughly the same way, and in which a test of a second kind monitors specifically bearers using large amounts of resources.

The method according to the invention is characterized by that, which is specified in the characterizing part of the independent method claim. The network element according to the invention is characterized by that, which is specified in the characterizing part of the independent claim directed to a network element. The dependent claims describe further advantageous embodiments of the invention.

In a method according to the invention, a bearer request is checked with two different tests before it is admitted or rejected. A test of a first kind is used for overall control, i.e. all bearers are treated in a roughly similar way. A test of a second kind is used for controlling bearers, which present a high load to the network. A bearer request must then pass a combination of a test of the first kind and a test of the second kind in order to be admitted. A two-part test according to the invention is able to efficiently handle both even and skewed traffic.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in more detail in the following with reference to the accompanying drawings, of which

Figure 1 illustrates a method according to an advantageous embodiment of the invention,

Figure 2 illustrates a method according to another advantageous embodiment of the invention,

Figure 3 illustrates an example of a test of the first kind according to an advantageous embodiment of the invention,

Figure 4 illustrates another example of a test of the first kind according to an advantageous embodiment of the invention,

Figure 5 illustrates an example of a test of the second kind according to an advantageous embodiment of the invention,

Figure 6 illustrates an example of a load curve used in some embodiments of the invention, and

Figure 7 illustrates further advantageous embodiments of the invention.

Same reference numerals are used for similar entities in the figures.

DETAILED DESCRIPTION

First, let us define some terms. In the following specification, non-controllable traffic means that part of the traffic in a cellular telecommunications system, which the network is required to transmit. Non-controllable traffic comprises real time (RT) bearers and the traffic caused by the minimum bit rate requirement of non-real-time (NRT) bearers. Controllable traffic comprises such traffic, which the network may transmit or whose transmission the network may delay according to available capacity. Controllable traffic comprises mainly the part of the traffic caused by NRT bearers, which is above the minimum required bit rate. Preferably, non-controllable traffic is used as a basis of predictions since controllable load can be adjusted according to changing new situations. In the following specification, the term control region means a cell, a sector of a cell or any other area under active power and admission control by a single entity. Typically, a control region comprises a single cell, or in the case of sectored cells, a single sector of a cell. The term own control region refers to the control region under control of a controlling entity, i.e. the control region being controlled by a method according to the invention.

A method according to the invention comprises a two-part admission control test, which the bearer must pass in order to be admitted. The two parts comprise a test of a first kind, which treats the bearers in a similar way without regard to differences in resource usage between bearers, and a test of a second kind, which concentrates on bearers consuming a large amount of air interface resources.

The two tests of the two-part test according to the invention can be combined in more than one way. According to an advantageous embodiment described with the help of figure 1, the requested bearer must pass separately each of the two tests. According to a further advantageous embodiment described with the help of figure 2, the results of a test of the second kind are used to adjust the admission criteria of a test of the first kind, which the requested bearer must pass in order to be admitted. In other words, in some embodiments of the invention a test of the second kind does not directly decide whether a requested bearer is admitted or not, but affects the admission decision indirectly by adjusting the admission requirements of a test of the first kind.

Figure 1 illustrates a method according to an advantageous embodiment of the invention. This embodiment illustrates the functioning of a two-part admission control test applied to a bearer request received by a cellular telecommunications network. First, it is checked 305 whether the bearer request is admissible according to a test of the first kind. If the bearer request is not admissible, then the request is refused 320 and the test is ended 325. If the bearer request was found to be admissible according to a test of the first kind, it is checked in the next step 310 whether the bearer request is admissible according to a test of the second kind. If the bearer request is not admissible, then the request is refused 320 and the test is ended 325. If the bearer request is admissible, then the bearer is admitted 315 and the test is ended 325.

Figure 2 illustrates a method according to a further advantageous embodiment of the invention. This embodiment illustrates the functioning of a two-part admission control test applied to a bearer request received by a cellular telecommunications network. First, it is checked 405 whether the bearer request satisfies a test of the second kind. If the bearer request satisfies the test, the method is continued at step 415. If the bearer request does not satisfy the test, admission criteria of the test of the first kind is changed 410, after which the method is continued at step 415. At step 415, it is checked whether the bearer request is admissible according to the test of the first kind. If the bearer request is not admissible, then the request is refused 420 and the test is ended 430. If the bearer request is admissible, then the bearer is admitted 425 and the test is ended 430.

In the following, examples of tests of the first kind are described, after which examples of tests of the second kind are described.

A. Examples of tests of the first kind

A.1. First example of a test of the first kind

In this example, the load is defined as the total power received by the receiver of the controlling entity in the control region, such as the receiver of the base station of a cell. For the purposes of admission control, the load due to non-controllable traffic is observed:

$$Load\_UL = Prx\_dBm_{current} = 10 \cdot \log_{10}(Prx_{intra,nc}) \qquad (1)$$

where $Prx_{intra,nc}$ is total received power of non-controllable traffic in the own control region. When a request to set up a new bearer is made, it is checked whether the

load remains under a predetermined threshold, if the requested bearer is admitted. This can be performed by forming an estimate Prx_dBm_{pred} of the received power in the case the requested bearer is admitted:

$$Prx\_dBm_{pred} = Prx\_dBm_{current} + Prx\_dB_{inc} \qquad (2)$$

where Prx_dB_{inc} is the estimated increase in the received power due to the new bearer. The estimate Prx_dBm_{pred} of the received power is compared to a threshold Prx_dBm_{th}, and if the following inequality holds

$$Prx\_dBm_{pred} < Prx\_dBm_{th} \qquad (3)$$

the bearer is admitted. The received power of the new bearer i.e. the estimated increase Prx_dB_{inc} in the received power due to the new bearer depends on the bit rate and SIR target level of the bearer. A coefficient k from the load curve can be used to estimate the received power Prx_dB_{inc} in the following way:

$$Prx\_dB_{inc} = k \cdot \frac{SIR_{target}}{PG} \qquad (4)$$

where PG is the processing gain. Obtaining of coefficient k is described in detail later in this specification.

Although equation (1) describes the calculations using dBm values, the invention is not limited to using dBm values. Therefore, the equations recited in this specification are only examples of feasible calculation methods, and do not limit the embodiments of the invention.

A.2. Second example of a test of the first kind

The previous example can be enhanced by taking into account the effect of at least some of the neighboring control regions. This can be effected by introducing a neighboring control region term into the previous equations. The neighboring control region term preferably comprises both controllable and non-controllable traffic, since from the point of view of the own control region being controlled, neither of them can be changed. The predicted load in the considered control region i can be calculated with the equations

$$Prx\_dBm_{current,i} = 10 \cdot log_{10}(Prx_{intra,nc,i} + Prx_{other,all,i}) \qquad (5)$$

$$Prx\_dBm_{total,pred,i} = Prx\_dBm_{current,i} + Prx\_dB_{inc} \tag{6}$$

where $Prx_{intra,nc,i}$ is the received power in the own control region due to non-controllable traffic in the region and $Prx_{other,all,i}$ is the received power in the control region due to traffic in other control regions. The term Prx_dB_{inc} in equation (6) can be estimated using equation (4). When using equations (5) and (6), the admission condition can be stated in the following way:

$$Prx\_dBm_{total,pred,i} < Prx\_dBm_{th} \tag{7}$$

A.3. Third example of a test of the first kind

In a further advantageous embodiment of the invention, statistical properties of different bearers are taken into account. A requested bearer is not taken into account as a single bit rate value, but rather as a distribution of bit rates.

First, a distribution of bit rates is created for at least some services i.e. bearer types. This may be performed for example by observing, how much of the time a certain bearer uses a certain bit rate, and repeating this observation for all bit rates used by the bearer. The bit rate distribution of a service does not usually change very quickly, wherefore distributions need not be collected very often.

In the following step, the distributions of existing bearers are convoluted to obtain the combined distribution of already existing bearers.

As an example of convolution of two distributions, let us consider the case of a speech and a video bearer. In this example, we assume that the speech bearer has a data rate of 0 kbit/s half of the time and 16 kbit/s for the other half of the time, i.e. both rates having the same probability of 0.5. Let us also assume that the video bearer has the following data rates and associated probabilities:

rate (kbit/s)	64	128	192	256	320	384
probability	0.1	0.3	0.1	0.3	0.1	0.1

When these two distributions are convoluted, we obtain the following combined distribution:

rate (kbit/s)	64	80	128	144	192	208	256	272	320	336	384	400
probability	0.05	0.05	0.15	0.15	0.05	0.05	0.15	0.15	0.05	0.05	0.05	0.05

Any number of distributions may be combined by convolution in this way. Since convolution is a common mathemathical tool and known by the man skilled in the art, calculation of convolutions is not described in further detail here.

As in some of the previously described embodiments, the transmissions from at least some of the neighbouring control regions may be taken into consideration. These transmissions can advantageously be represented by a predefined default distribution in the calculation of the convolutions, which predefined default distribution can be scaled before the convolution operation in order to match the observed interference level. Noise parameters may also conveniently be included in the calculations in a similar way as the transmission from neighbouring control regions.

However, in some embodiments of the invention according to the third example of a test of the first kind, the effect of the other control regions may be left out of consideration in order to simplify the calculations.

In the following step, a distribution for the requested bearer is determined. This is advantageously performed by selecting from a predefined library of distributions, one distribution which corresponds most closely to the properties of the requested bearer. The predefined library may comprise one, two or more predefined distributions. Preferably, the library comprises several predefined distributions corresponding to most typical bearer types.

The distribution for the requested bearer may also be obtained by scaling a default distribution to match the requested bearer properties, in which case a single default distribution may be used for all cases, or a default distribution may be chosen from a library of default distributions.

In a further advantageous embodiment of the invention, the distribution of the requested bearer is obtained by interpolation from two library distributions, or by combining several library distributions.

After determination of the distribution of the requested bearer, the distribution is convoluted with the distribution of already existing bearers for obtaining a predicted distribution.

In the following step, it is checked if the predicted distribution is within the required limits. This may be performed in many different ways, depending on how the limits are specified and how a distribution of values can be determined to be within the limit or limits. For example, the checking may be effected in one of the following ways a) to d).

a) A cumulative sum of the predicted distribution is calculated, beginning from the lowest bit rate values. Cumulative sum is calculated until a certain predefined value is exceeded. The rate at which the predefined value is exceeded, is compared to a threshold value. If the rate is lower than the threshold, the bearer passes this test.

b) The predicted distribution is weighted by a constant multiplier or by a weighting distribution before calculation of the cumulative sum and comparing as in a).

c) The predicted distribution is processed in some other way, for example a predefined function may calculate a value which is compared to a threshold value. Different bit rates can be weighted differently by construction of the predefined function. The admission control can be adjusted in many ways by choosing a suitable predefined function for obtaining the intended purpose: for example, to prefer low bit rate bearers or to prefer high bit rate bearers, or give preference to bearers having a bit rate within a specified bit rate range in order to guarantee better service to a certain service or a group of services. The function may also be constructed in such a way as to produce such admission control criteria, that all bearers are given equal preference regardless of their resource usage.

d) The threshold can be expressed as a distribution, which is directly compared with the predicted distribution. For example, the bearer can be refused, if the predicted distribution is higher than the threshold distribution at some load value.

Such embodiments of the invention which consider the existing bearers as distributions have the additional advantage, that a temporary deviation of the bit rate of a bearer from the nominal value does not affect the determination of the load. For example, if the load presented by a bearer is determined at any single instant, it might not represent the average load the bearer presents. This problem can be

avoided by expressing the load presented by a bearer as a distribution, which represents the actual load more accurately than a single measurement.

Figure 3 illustrates a test according to the third example of a test of the first kind. First, the combined distribution of existing bearers is determined in step 110. The combined distribution may be determined for example by any of the previously described ways. In the next step 115, the distribution of the requested bearer is determined for example by selecting a distribution from a set of predefined distributions, which distribution has properties corresponding to the properties of the requested bearer. In the next step 120, the distribution of the requested bearer is combined with the distribution of all bearers to form a predicted distribution. If the predicted distribution is found to be outside the admission limits in step 125, the request is refused in step 130 and the test is ended 140. If the predicted distribution is found to be within the admission limits in step 125, the bearer passes 135 this test and the test is ended 140.

A.4. Fourth example of a test of the first kind

In a further advantageous embodiment of the invention, the transmission power is taken into account when determining the load distributions. This gives a better representation of the actual load situation than only bit rate based distributions. The transmission power can be taken into account in several different ways, for example in one of the following ways:

- A distribution may represent the distribution of the received power of a bearer.
- A distribution may represent the distribution of received energy per bit of a bearer.
- A distribution may represent the distribution of the bit rate of the bearer, weighted by the average energy per bit value of a bearer.
- A distribution may represent the distribution of the bit rate of the bearer, weighted by the average energy per bit value of a bearer.
- A distribution may represent the distribution of the bit rate of a bearer, weighted with the probability distribution of the received power of the bearer.

However, the invention is not limited to only these examples of ways of constructing distributions indicating at least in part a measure of transmitted energy.

Since the energy per bit values may be difficult to determine, an estimate of the average energy per bit value may be obtained for example from an estimate of the average transmission power of the bearer and the average bit rate of the bearer.

In other respects, the embodiments according to the fourth example of a test of the first kind may use the methods described previously with bit rate distributions according to the third example of a test of the first kind, by replacing the bit rate distributions with distributions according to the fourth example of a test of the first kind.

A.5. Fifth example of a test of the first kind

The previously described third and fourth examples of a test of the first kind are computationally relatively intensive. To reduce the amount of calculations needed, the bearers can be treated in bearer groups to simplify the formation of the combined distribution of existing bearers. A bearer group is preferably a group of bearers having roughly similar BER requirement, i.e. roughly the same received energy per bit requirement. The bearers can also be grouped on the basis of the shape of their distributions.

The combined distribution of existing bearers can be determined for example as follows. First, the existing bearers are grouped to one or more bearer groups. Then, a distribution is determined for each group, preferably by selecting a distribution from a library of predefined distributions. Alternatively, certain bearer group types can be predefined, each with an associated predefined distribution. The distribution of each group is scaled to represent the total load represented by all of the bearers of the group. In the next step, the scaled group distributions are combined to form the combined distribution of existing bearers, preferably by convolving the distributions as described previously.

Next, the distribution of the requested bearer is determined. After that step, the predicted probability distribution is determined, which is preferably performed by combining the distribution of the requested bearer with the combined distribution of existing bearers.

Testing of whether the predicted distribution is within admission limits can be performed as described previously in the third example of a test of the first kind.

In a further embodiment according to the fifth example of a test of the first kind, the requested bearer is taken into account already before the combining of the group distributions. In such an embodiment, the requested bearer is taken into account by an additional scaling of the distribution of that bearer group, which most closely corresponds to the requested bearer. As a consequence, the result of the combining of group distributions is directly the predicted distribution.

Figure 4 illustrates a test according to the fifth example of a test of the first kind. In this example of an embodiment of the invention, the existing bearers are first grouped in bearer groups in step 205. In the next step 210, the distributions of the bearer groups are determined for example by selecting from a set of predefined distributions, after which each distribution is scaled in step 215 to match the load presented by the corresponding group of bearers. The scaled group distributions are combined in step 220 to obtain a combined distribution of existing bearers. In the next step 225, the distribution of the requested bearer is determined for example by selecting a distribution from a set of predefined distributions, which distribution has properties corresponding to the properties of the requested bearer. In the next step 230, the distribution of the requested bearer is combined with the distribution of all bearers to form a predicted distribution. If the predicted distribution is found to be outside the admission limits in step 235, the request is refused in step 240 and the test is ended 250. If the predicted distribution is found to be within the admission limits in step 235, the bearer passes 245 this test and the test is ended 250.

B. Examples of tests of the second kind

The tests of the second kind concentrate on bearers, which require relatively large amounts of resources. Such bearers are denoted in the following by the term high load (HL) bearer. A bearer may be a HL bearer for example if the bit rate of the bearer is high, if the transmission power of the bearer is high, or the energy per transmitted bit E_b is high. The thresholds determining if a bearer is a normal i.e. a low load bearer or a high load bearer may be defined in many different ways according to the needs of the particular implementation of the invention, and the invention is not limited to any specific such threshold or way of determining whether a bearer is a HL bearer or not.

Since the bit rate of a bearer is straightforward to monitor, the bit rate can advantageously be used for determining whether a bearer is a normal or a HL bearer. The bit rate threshold for the determination can be adjusted for example by

experimenting with different values of the threshold and choosing the value producing the optimum performance of the network. The bit rate threshold may be different in different control regions. Further, in some embodiments of the invention the network may adjust the bit rate threshold in a control region according to the traffic situation.

In the following examples of tests of the second kind, the first four present tests of the second kind, which can be used in a method according to figure 1, and the rest present tests of the second kind, which can be used in a method according to figure 2.

B.1. First example of a test of the second kind

According to a further advantageous embodiment of the invention, problems created by a skewed load is alleviated by preventing the admission of too many high load bearers to one control region. The admission or rejection of HL bearers is in an advantageous embodiment of the invention performed simply on the basis of the number of HL bearers already active in a control region. A new bearer passes this test if the following inequality holds:

$$HL_i + HL_{new} \leq HL_{th1} \qquad (8)$$

where

HL_i	is the number of existing HL bearer in the control region i
HL_{new}	is 1 if the new bearer is a HL bearer, otherwise 0, and
HL_{th1}	is the predetermined maximum number of HL bearers in one control region.

The addition of 1 in equation (8) is not essential in various embodiments of the invention according to the first example of a test of the second kind. The test may simply be a comparison of HL_i to a threshold, in which case only HL bearers are required to pass this comparison.

B.2. Second example of a test of the second kind

In a further advantageous embodiment of the invention, the previously described first example of a test of the second kind is enhanced by taking the neighbouring control regions into account as well. In such an embodiment, the admission condition can be for example the following:

$$\sum_{i=1}^{nearbyBSs} HL_i + HL_{new} \le HL_{th2} \tag{9}$$

where HL_{th2} is the maximum number of HL bearers within the own control region and the considered neighbouring control regions. The sum is calculated over a desired number of nearby control regions, for example all directly neighbouring control regions.

Figure 5 illustrates a test according to the first or the second example of a test of the second kind. In figure 5, the existing high load bearers are counted in step 260. The counting may be done over the own control region as in the first example of a test of the second kind, or for example over the directly neighbouring control regions as in the second example of a test of the second kind. In the next step 265, the result is incremented by one, if the requested bearer is a high load bearer. In the next step 270 the result is compared to a predefined threshold value. If the result is larger than the threshold, the request is refused in step 280 and the test is ended. If the result is smaller than or equal to the threshold, the bearer is determined to pass 275 this test and the test is ended 285.

B.3. Third example of a test of the second kind

In a further advantageous embodiment of the invention, instead of the number of HL bearers as in equations (8) and (9), the admission condition can be based on the sum of bit rates of HL bearers in a control region or a group of control regions. This sum is then compared to a predefined threshold sum. If the predefined threshold sum is smaller than the sum of bit rates, the requested bearer is refused.

In a still further advantageous embodiment of the invention, the admission condition is based on the sum of bit rates of HL bearers as a percentage of total combined bit rate of all bearers within a control region or a group of control regions. This percentage sum is then compared to a predefined threshold percentage value. If the threshold value is smaller than the sum, the requested bearer is refused.

B.4. Fourth example of a test of the second kind

In a further advantageous embodiment of the invention, the admission condition can be based on the sum of transmission power of existing HL bearers in a control

region or a group of control regions. The sum is compared to a predefined threshold value, and if the threshold value is smaller than the sum, the requested bearer is refused.

B.5. Fifth example of a test of the second kind

In a further advantageous embodiment of the invention, the result of a test of the second kind is used to control the admission threshold used in a test of the first kind. This may be effected in many different ways, examples of which are presented in the following.

- For example, the admission threshold may be changed by a predefined amount if one or more HL bearers already exist.
- For example, the admission threshold may be changed by a predefined amount once for each HL bearer already existing.
- For example, the sum of bit rates of HL bearers may be computed and the sum compared to a predefined maximum value, and the admission threshold may be changed according to the ratio of the sum to the predefined maximum value.
- For example, the total transmission power of HL bearers may be determined and compared to a predetermined maximum value, and the admission threshold may be changed according to the ratio of the total transmission power and the predetermined maximum value.

However, the invention is not limited to these examples of ways, in which the admission threshold used in a test of the first kind can be changed according to the result of a test of the second kind. Other ways may be used in various embodiments of the invention. For example, in some embodiments of the invention the HL bearers in neighbouring control regions are taken into account.

B.6. Sixth example of a test of the second kind

In those embodiments of the invention, in which bearers are processed as distributions and a predicted distribution is obtained in the test of the first kind, the admission control adjustment may be effected in a wide variety of ways depending on how the predicted distribution is determined to be within admission criteria or outside the admission criteria. In such an embodiment the admission criteria can be adjusted uniformly for all bearers, or adjusted to be stricter to certain bearer types

only. For example, the admission criteria can be adjusted to be stricter for new HL bearers while retaining the previous admission criteria for normal bearers.

Further, instead of adjusting the predefined admission limits, the processing of the predicted distribution can be adjusted for effecting the desired changes in admission requirements. For example, the predicted distribution can be weighted with a suitable distribution emphasizing the high bit rate values, which results in less resources being available to high load bearers. Further, if a predefined function calculates a value based on the predicted distribution, and this value is then compared to a predefined threshold for obtaining the admission decision, the function can be changed for effecting the desired changes in admission requirements.

C. Further considerations

In various embodiments described previously, the estimated increase Prx_dB_{inc} in received power due to a new bearer is estimated with the help of a load curve. A load curve can be obtained as follows. It is generally known that SIR value SIR_i of a bearer i may be calculated as

$$SIR_i = PG_i \cdot \frac{Prx_i}{\sum_{\substack{j=1 \\ j\neq i}}^{N} Prx_j + P_a} \qquad (10)$$

where PG_i is the processing gain of the bearer, Prx_i is the received power of the bearer i, the sum in the denominator is performed over the received power of other bearers, and the term P_a denotes other interference sources and noise. From this follows

$$\frac{SIR_i}{PG_i} = \frac{Prx_i}{\sum_{\substack{j=1 \\ j\neq i}}^{N} Prx_j + P_a} \qquad (11)$$

Summing SIR_i / PG_i over many bearers and allowing the number of bearers go to infinity, we obtain the limit

$$\sum_{i=1}^{N} \frac{SIR_i}{PG_i} \xrightarrow[N\to\infty]{} 1 \qquad (12)$$

A load curve can be obtained by plotting $\sum Prx_i$ as a function of $\sum (SIR_i / PG_i)$. An example of a load curve is given in figure 6. The load curve has an roughly linear portion in the middle. The coefficient k mentioned previously can be obtained from the load curve as the slope of a part of the roughly linear portion of the load curve. The coefficient k can also be found out by measuring the received total power level, i.e. $\sum Prx_i$, at different traffic situations with different numbers of active bearers i.e. at different values of $\sum (SIR_i / PG_i)$, and fitting a straight line into the measurement data. The slope of the line may then be used as the coefficient k.

The method according to the invention can be used as well in bearer negotiations i.e. if a first bearer request does not pass, a second bearer request with different parameters can be examined and so on, until admissible bearer parameters are found.

The method according to the invention can advantageously be used in a radio network controller (RNC) or other cellular telecommunications network element performing admission control. The method according to the invention can advantageously be applied in the UMTS cellular telecommunication system and other telecommunications systems at least partly based on the CDMA technology. The name of a given functional entity, such as the radio network controller, is often different in the context of different cellular telecommunication systems. For example, in the GSM system the functional entity corresponding to a radio network controller (RNC) is the base station controller (BSC).

D. Further embodiments of the invention

According to an advantageous embodiment, means for realizing the inventive method are incorporated in a network element of a telecommunications network. One example of such a network element is the radio network controller of a cellular telecommunications network. Figure 7 illustrates one example of such an embodiment. Figure 7 shows mobile stations 505 which are in radio connection with base stations 510. The base stations are connected to and controlled by a radio network controller 520, which is in turn connected to rest of the cellular telecommunications network 550. The cellular telecommunications network may,

for example, be the UMTS cellular telecommunications network presently under development. According to this embodiment, the radio network controller comprises means 521, 522, 523 for testing a bearer request according to a test of a first kind and for producing a first test result, means 521, 522, 524 for testing a bearer request according to a test of a second kind and producing a second test result, and means 521, 522, 525 for deciding about admission of the bearer on the basis of said first and second test result. These means may be for example, a processing unit 521 such as a microprocessor 521 or a digital signal processor 521, a memory unit 522 comprising programs 523, 524, 525 executed by the processing unit 521 for performing the test of the first kind and test of the second kind and producing the admission or rejection decision based on the results of the tests for example according to the examples of methods recited previously.

The threshold values of admission conditions do not need to be permanently fixed values. The threshold values may be adjusted by the controlling entity of the control region or another element of the cellular telecommunications network in various embodiments of the invention, for example to optimize the resource usage of the network.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications and variations may be made to the above-presented exemplary embodiments of the invention.

Claims

1. An admission control method for handling bearer requests in a cellular telecommunications network that supports bearers that are allowed to comprise controllable load components in addition to non-controllable traffic load components,
characterized in that it comprises sequentially the steps of:
- testing a bearer request with a test of a first kind (305, 415) that sets criteria for non-controllable traffic load components in an essentially similar way for all bearer requests, and
- said bearer request is tested with a test of a second kind (310, 405);
wherein said test of a second kind (310, 405) monitors bearers that present to the network a non-controllable load component which exceeds a predefined threshold, and the admission (315, 420) of said bearer request depends on the results of both said test of a first kind (305, 415) and said test of a second kind (310, 405).

2. Admission control method according to claim 1, **characterized** in that said test of a first kind (305, 415) is based on statistical properties (110, 115, 120) of bearers.

3. Admission control method according to claim 1, **characterized** in that in said test of a second kind (310, 405) the number (260, 265) of currently existing high load bearers is compared (270) to a predefined threshold.

4. Admission control method according to claim 1, **characterized** in that in said test of a second kind (310, 405) the sum of bit rates of currently existing high load bearers and of the requested bearer is compared to a predefined threshold.

5. Admission control method according to claim 1, **characterized in** that the admission criteria of said test of a first kind (415) are changed (410) according to the results of said test of a second kind (405).

6. Admission control method according to claim 5, **characterized** in that an admission threshold of said test of a first kind (305, 415) is changed by a predefined step, if at least one high load bearer exists already.

7. Admission control method according to claim 6, **characterized** in that an admission threshold of said test of a first kind (305, 415) is changed by a second predefined step for each high load bearer existing already.

8. Network element (520) for a cellular telecommunications network that supports bearers that are allowed to comprise controllable load components in addition to non-controllable traffic load components, **characterized** in that the element comprises

- means (521, 522, 523) for testing a bearer request according to a test of a first kind that sets criteria for non-controllable traffic load components in an essentially similar way for all bearer requests, and for producing a first test result,

- means (521, 522, 524) for testing a bearer request, sequentially with said test of a first kind, according to a test of a second kind that monitors bearers that present to the network a non-controllable load component which exceeds a predefined threshold, and producing a second test result, and

- means (521, 522, 525) for deciding about admission of the bearer on the basis of said first and second test results.

9. Network element (520) for a cellular telecommunications network according to claim 8, **characterized in** that the network element is a radio network controller.

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY Includes Reference to PCT International Applications	Attorney's Docket No.

As a below named inventor, I hereby declare that:

By Express Mail
No. EL726283277US

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

ADMISSION CONTROL METHOD

the specification of which (check only one item below)

[X] is attached hereto

[] was filed as United States application

Serial No. _

on _

and was amended

on _ (if applicable).

[X] was filed as PCT international application

Number PCT/FI99/00794

on 28 September 1999

and was amended under PCT Article 19

on _ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

PRIOR FOREIGN/PCT APPLICATIONS AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

Country (if PCT, indicate "PCT")	Application Number	Date of Filing (day, month, year)	Priority Claimed Under 35 U.S.C. 119	
Finland	982091	Sept. 29, 1998	[x] YES	[] NO
PCT	PC/FI99/00794	Sept. 28, 1999	[x] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	Attorney's Docket No.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS			STATUS *(check one)*		
U.S. APPLICATION NUMBER		U.S FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED *(if any)*			
PCT/FI99/00794	Sept. 29, 1999				

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*List name and registration number*)

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SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
[illegible]		
DATE 6.3.2001	DATE	DATE